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PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 06 April 2001 (06.04.01)	
International application No. PCT/NO99/00324	**Applicant's or agent's file reference** P9945
International filing date (day/month/year) 25 October 1999 (25.10.99)	**Priority date** (day/month/year) 02 July 1999 (02.07.99)
Applicant PETTERSEN, Ketil et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

18 January 2001 (18.01.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Claudio Borton

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P9945		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NO99/00324	25/10/1999	02/07/1999
International Patent Classification (IPC) or national classification and IPC C22C23/02		
Applicant NORSK HYDRO ASA et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
18/01/2001	17.07.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Noske, W Telephone No. +49 89 2399 8448

Form PCT/IPEA/409 (cover sheet) (January 1994)

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-8
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-5
	No:	Claims	6-8
Industrial applicability (IA)	Yes:	Claims	1-8
	No:	Claims	

2. Citations and explanations
   see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

1. Nearest prior art are Mg based alloys AS21 and AS41 as mentioned in the application, p. 1.
   The Mg based Al containing alloy according to claim 1 departs from the nearest prior art in presence of 0.01-0.4 wt.-% RE.
   Novelty of the subject-matter of claims 1-5 thus is given.
   None of the prior art documents suggests a low content of RE as claimed in a Mg based Al containing alloy comprising Si and Mn in amounts as claimed.
   The claimed content of RE controls the impurity content of Fe to low values and improves corrosion resistance without impairing mechanical properties.
   The only document providing a content of RE which overlaps the claimed range of 0.01-0.4% RE in a Mg based Al containing alloy is
   D2 EP-A-524644, abstract and claim 13,
   disclosing contents of 0.1 - 3% RE for providing crystals having a high melting point and improving high temperature strength, however in an alloy which does not comprise Mn, necessarily includes a higher content of Zn and allows a broader range of Si than claimed.
   D2 does not suggest the composition claimed in claims 1-5 in order to improve corrosion resistance.
   An inventive step is thus also given.
2. Independent claim 6 leaves open the composition of the Mg-Al-Si-Mn-RE-alloy mentioned therein.
   It thus allows any compositional ranges of the said alloying elements and undefined additions of any further alloying elements, which would render the alloy unusable and prevent the object of the invention to be attained. It is remarked that undesirable effects and/or unusability regularly result already from small additions of undesirable alloying elements.
   Since claim 6 thus comprises subject-matter which cannot solve the problem underlying the application it does not comprise anything inventive.
   The same objection is valid for dependent claims 7 and 8.
3. The indefinite formulation of 6-9 renders the claimed subject-matter unclear, Art. 6 PCT. An invention lying in an alloy composition requires 100% of the composition to be claimed.

Patent claims

1. Magnesium based alloy with improved corrosion resistance, containing 1.5-5 weight % Al, 0.6-1.4 weight % Si, 0.01-0.6 weight % Mn, 0.01-0.4 weight % RE, up to 0.5 weight % Zn, the balance being Mg and impurities.

2. Magnesium alloy according to claim 1, wherein the Zn content is in the range 0.1-0.3 weight %.

3. Magnesium alloy according to claim 1, wherein the Mn content is in the range 0.01-0.3 weight %.

4. Magnesium alloy according to claim 1, wherein the rare earth elements are Misch metal.

5. Magnesium alloy according to claim 1, containing 1.9-2.5 weight % Al, 0.7-1.2 weight % Si, 0.15-0.25 weight % Zn, 0.01-0.3 weight % RE and 0.01-0.2 weight % Mn, the balance being Mg and impurites.

6. Method of improving the corrosion resistance of magnesium-aluminium-silicon alloys, where Mn is added in order to reduce Fe impurities, by keeping both Mn and Fe at a low level by adding small amounts of RE.

7. Method according to claim 6, wherein the Mn content is kept above 0.01 weight %.

8. Method according to claim 6, wherein the RE content is kept in the range 0.01-0.4 weight %.

EP-A-524644 describes an Mg-Al-Zn-RE alloy that is based on formation of Mg-Al-Zn-RE crystals to obtain creep resistance. Zn improves room temperature strength of the Mg alloy and enhances castability. In order to obtain these advantageous effects it is necessary to include Zn in an amount of 1.0 weight % or more. It is based on use of Zr to remove iron for better corrosion resistance. Si is given as an element that gives a further enhancement of the properties, but both Zn and Zr are essential elements in this alloy.

P9945P

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

Elin: E

ANDERSON, Elin
Norsk Hydro ASA
N-0240 Oslo
NORVÈGE

MOTTATT I N.H.
PATENTAVD.
1 3 DES 1999

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
30 November 1999 (30.11.99)	
Applicant's or agent's file reference	**International application No.**
P9945	PCT/NO99/00324

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

NORSK HYDRO ASA (for all designated States except US)
PETTERSEN, Ketil et al (for US)

International filing date	:	25 October 1999 (25.10.99)
Priority date(s) claimed	:	02 July 1999 (02.07.99)
Date of receipt of the record copy by the International Bureau	:	23 November 1999 (23.11.99)
List of designated Offices	:	

AP :GH,GM,KE,LS,MW,SD,SL,SZ,TZ,UG,ZW
EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
National :AE,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CU,CZ,DE,DK,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,NO,NZ,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,US,UZ,VN,YU,ZA,ZW

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [X] confirmation of precautionary designations
- [ ] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

J. Leitao

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

ANDERSON, Elin
Norsk Hydro ASA
N-0240 Oslo
NORVÈGE

Date of mailing (day/month/year) 30 November 1999 (30.11.99)	
Applicant's or agent's file reference P9945	**IMPORTANT NOTIFICATION**
International application No. PCT/NO99/00324	International filing date (day/month/year) 25 October 1999 (25.10.99)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 02 July 1999 (02.07.99)
Applicant NORSK HYDRO ASA et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
02 July 1999 (02.07.99)	19993289	NO	23 Nove 1999 (23.11.99)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

J. Leitao

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

WO 01/02614
PCT/NO99/00324

P9945 PCT

From the INTERNATIONAL BUREAU

PCT

To:
ANDERSON, Elin
Norsk Hydro ASA
N-0240 Oslo
NORVÈGE

Sett.
EA

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

Date of mailing (day/month/year) 11 January 2001 (11.01.01)	
Applicant's or agent's file reference P9945	**IMPORTANT NOTICE**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/NO99/00324 ✓	25 October 1999 (25.10.99) ✓	02 July 1999 (02.07.99) ✓

Applicant
NORSK HYDRO ASA et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CU,CZ,DE,DK,EA,EE,EP,ES,FI,GB,GD,GE,GH,
   GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,NO,NZ,
   OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   11 January 2001 (11.01.01) under No. WO 01/02614

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* P9945

Box No. I TITLE OF INVENTION

"Magnesium alloy"

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

NORSK HYDRO ASA
N-0240 Oslo
Norway

☐ This person is also inventor.

Telephone No.
+47 22 43 21 00

Facsimile No.
+47 22 43 23 08

Teleprinter No.

State *(that is, country)* of nationality: Norway

State *(that is, country)* of residence: Norway

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

PETTERSEN, Ketil
Gråsteinveien 14
N-3931 Porsgrunn
Norway

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is,country)* of nationality: Norway

State *(that is, country)* of residence: Norway

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

ANDERSON, Elin
Norsk Hydro ASA
N-0240 Oslo
Norway

Telephone No.
+ 47 22 43 29 18

Facsimile No.
+47 22 43 23 08

Teleprinter No.

☐ **Adress for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

VIDEM, Marianne
Tømmerveien 54
N-3943 Porsgrunn
Norway

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: Norway

State *(that is, country)* of residence: Norway

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☒ the United States of America only
- ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SKAR, Jan Ivar
Lærer Johnsens vei 2
N-3960 Stathelle
Norway

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: Norway

State *(that is, country)* of residence: Norway

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☒ the United States of America only
- ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☐ the United States of America only
- ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☐ the United States of America only
- ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- [X] **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- [X] **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- [X] **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- [X] **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- [X] **AE** United Arab Emirates
- [X] **AL** Albania
- [X] **AM** Armenia
- [X] **AT** Austria
- [X] **AU** Australia
- [X] **AZ** Azerbaijan
- [X] **BA** Bosnia and Herzegovina
- [X] **BB** Barbados
- [X] **BG** Bulgaria
- [X] **BR** Brazil
- [X] **BY** Belarus
- [X] **CA** Canada
- [X] **CH and LI** Switzerland and Liechtenstein
- [X] **CN** China
- [X] **CU** Cuba
- [X] **CZ** Czech Republic
- [X] **DE** Germany
- [X] **DK** Denmark
- [X] **EE** Estonia
- [X] **ES** Spain
- [X] **FI** Finland
- [X] **GB** United Kingdom
- [X] **GD** Grenada
- [X] **GE** Georgia
- [X] **GH** Ghana
- [X] **GM** Gambia
- [X] **HR** Croatia
- [X] **HU** Hungary
- [X] **ID** Indonesia
- [X] **IL** Israel
- [X] **IN** India
- [X] **IS** Iceland
- [X] **JP** Japan
- [X] **KE** Kenya
- [X] **KG** Kyrgyzstan
- [X] **KP** Democratic People's Republic of Korea
- [X] **KR** Republic of Korea
- [X] **KZ** Kazakhstan
- [X] **LC** Saint Lucia
- [X] **LK** Sri Lanka
- [X] **LR** Liberia
- [X] **LS** Lesotho
- [X] **LT** Lithuania
- [X] **LU** Luxembourg
- [X] **LV** Latvia
- [X] **MD** Republic of Moldova
- [X] **MG** Madagascar
- [X] **MK** The former Yugoslav Republic of Macedonia
- [X] **MN** Mongolia
- [X] **MW** Malawi
- [X] **MX** Mexico
- [X] **NO** Norway
- [X] **NZ** New Zealand
- [X] **PL** Poland
- [X] **PT** Portugal
- [X] **RO** Romania
- [X] **RU** Russian Federation
- [X] **SD** Sudan
- [X] **SE** Sweden
- [X] **SG** Singapore
- [X] **SI** Slovenia
- [X] **SK** Slovakia
- [X] **SL** Sierra Leone
- [X] **TJ** Tajikistan
- [X] **TM** Turkmenistan
- [X] **TR** Turkey
- [X] **TT** Trinidad and Tobago
- [X] **UA** Ukraine
- [X] **UG** Uganda
- [X] **US** United States of America
- [X] **UZ** Uzbekistan
- [X] **VN** Viet Nam
- [X] **YU** Yugoslavia
- [X] **ZA** South Africa
- [X] **ZW** Zimbabwe

Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

- [X] TZ Tanzania
- [X] MA Marocco

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn bythe applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 02 Jul. 1999 (02.07.99)	19993289	Norway		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

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Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

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This international application contains the following **number of sheets**:

request	: 4
description (excluding sequence listing part)	: 10
claims	: 1
abstract	: 1
drawings	: 9
sequence listing part of description	:
Total number of sheets	: 25

This international application is **accompanied by** the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
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8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other *(specify)*:

Figure of the drawings which should accompany the abstract: 9

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Elin Anderson

Elin Anderson

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(71) Applicant *(for all designated States except US)*: **NORSK HYDRO ASA** [NO/NO]; N-0240 Olso (NO).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **PETTERSEN, Ketil** [NO/NO]; Gråsteinveien 14, N-3931 Porsgrunn (NO). **VIDEM, Marianne** [NO/NO]; Tømmerveien 54, N-3943 Porsgrunn (NO). **SKAR, Jan, Ivar** [NO/NO]; Lærer Johnsens vei 2, N-3960 Stathelle (NO).

(74) Agent: **ANDERSON, Elin**; Norsk Hydro ASA, N-0240 Oslo (NO).

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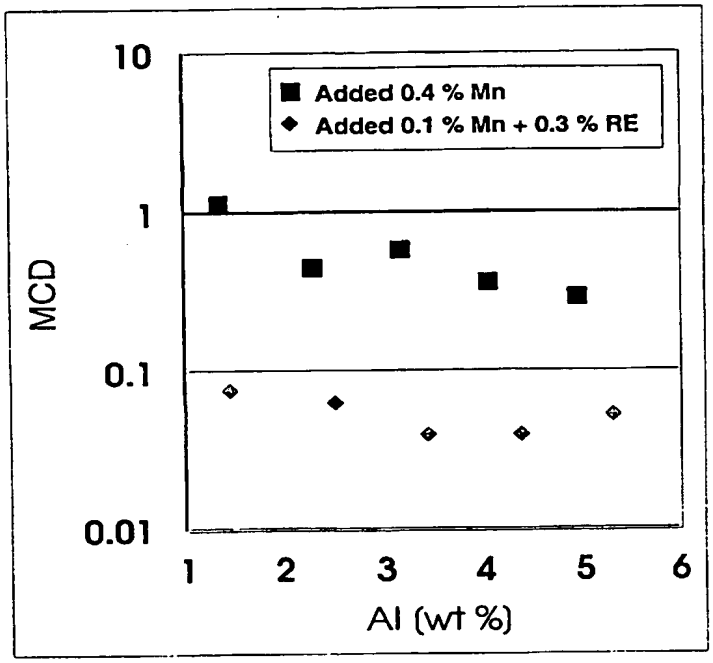
(54) Title: CORROSION RESISTANT Mg BASED ALLOY CONTAINING Al, Si, Mn AND RE METALS



(57) Abstract: Magnesium alloy with improved corrosion resistance comprising magnesium, 1.5-5 weight % Al, 0.6-1.4 weight % Si, 0.01-0.6 weight % Mn and 0.01-0.4 weight % RE. Method of improving the corrosion resistance of magnesium, aluminium, silicon alloys where Mn is added in order to reduce FE impurities, by keeping both Mn and Fe at a low level by adding small amounts of RE.

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CORROSION RESISTANT Mg BASED ALLOY CONTAINING Al, Si, Mn AND RE METALS

Such alloys are used for die casting of for example automotive, transmission and engine parts. Therefore the alloy needs to have good mechanical properties also at elevated temperatures. Alloys for this use available on the market today include AS21, AS41 and AE42. The alloy AS21 has the following composition (Hydro Magnesium Specifications), 1.9-2.5 weight % Al, minimum 0.2 weight % Mn, 0.15-0.25 weight % Zn, 0.7-1.2 weight % Si, maximum 0.008 weight % Cu, maximum 0.001 weight % Ni, maximum 0.004 weight % Fe and maximum 0.01 weight % of other elements each. The alloy AS41B (ASTM B93-94a) contains 3.7-4.8 weight % Al, 0.35-0.6 weight % Mn, maximum 0.10 weight % Zn, maximum 0.60-1.4 weight % Si, maximum 0.015 weight % Cu, maximum 0.001 weight % Ni, maximum 0.0035 weight % Fe and maximum 0.01 weight % of other elements each. The alloy AE42 (Hydro Magnesium Specifications) contains 3.6-4.4 weight % Al, minimum 0.1 weight % Mn, maximum 0.20 weight % Zn, maximum 0.04 weight % Cu, maximum 0.001 weight % Ni, maximum 0,004 weight % Fe, 2.0-3.0 weight % RE and maximum 0.01 weight % of others each. RE refers to rare earth elements. All these alloys contain some iron and as iron is detrimental to the corrosion properties of magnesium aluminium alloys, manganese is used to control and reduce the iron content in the alloys.

In spite of this, the corrosion resistance of for example AS21 is not sufficient in e.g. automotive use. Car parts are subjected to a harsh environment especially at winter time when de-icing agents are applied to the roads. The alloy AE42 has good corrosion properties also in this environment, but it is more expensive than e.g. AS21. In addition, the casting properties are not as good as for the others, particularly due to a tendency to stick and solder to the die.

Alloys of this type are also described for example in Norwegian patent No. 121 753 , US patent No. 3 718 460 and French patent No. 1 555 251.

The object of the invention is to improve the corrosion resistance without detoriation of basic properties of magnesium-aluminium-silicon alloys. Another object is to avoid increased costs of the alloy.

These and other objects of the invention are obtained by the alloy as described below. The invention is further described and characterized by the accompanying patent claims.

The invention concerns a magnesium based alloy with improved corrosion resistance, containing 1.5-5 weight % Al, 0.6-1.4 weight % Si, 0.01-0.6 weight % Mn, 0.01-0.4 weight % RE. The content of impurities should be kept at a low level with maximum 0.008 weight % Cu, maximum 0.001 weight % Ni, maximum 0.004 weight % Fe and maximum 0.01 weight % of other elements each. Particularly, a Mn content of 0.05 - 0.2 weight % is favorable. In addition, it is preferable to add until 0.5 weight % Zn and especially 0.1- 0.3 weight % Zn. This element has a positive effect on corrosion resistance. The rare earth elements used are preferably in the form of Misch metal. A preferred alloy contains 1.9-2.5 weight % Al, 0.7-1.2 weight % Si, 0.15-0.25 weight % Zn, 0.01-0.3 weight % RE and 0.01-0.2 weight % Mn. The invention also concerns a method of improving the corrosion resistance of magnesium, aluminium, silicon alloys where Mn is added in order to reduce Fe impurities, by keeping both Mn and Fe at a low level by adding small amounts of RE. It is preferred to keep the Mn content above 0.01 weight % and the RE content in the range 0.01-0.4.

The invention will be further illustrated with reference to Figures 1-9, where

Figure 1 shows the combination of Mn and RE content found in the the investigated specimens. These compositions span the temperature range from 650 °C - 720 °C. The mutually limited solubility of Mn and RE restricts the investigation to the lower left half of the figure.

Figure 2 shows the Fe content in the specimens analyzed in the test program.

Figure 3 shows corrosion rates (MCD = mg/cm²day) of immersion tested of gravity cast disc samples versus RE and Mn content of the investigated specimens.

Figure 4 shows corrosion rates versus Mn and Fe content of the investigated specimens. The results are from 72 hours immersion tests of gravity cast disc samples.

Figure 5 shows corrosion rates versus RE content and casting temperature for the gravity cast disc samples containing minimum 0.045 weight% Mn.

Figure 6 shows corrosion rates versus Mn and RE content of the investigated die cast plates. In this investigation the Mn and the RE contents were varied in the range 0.05 - 0.35 weight%.

Figure 7 shows corrosion rates for the die cast plates, tested in salt spray for 240 hours according to ASTM B117, versus Mn and Fe content. The trends as observed in the immersion tests of the gravity cast disc samples are also found here.

Figure 8 shows the individual corrosion test results versus Al-content for two series of alloys.

Figure 9 shows mean values of corrosion test results versus Al-content for two series of alloys when the outliers are excluded.

The present findings show that it is possible to significantly improve the corrosion resistance of magnesium alloys with aluminium and silicon by the addition of small amounts of Rare Earth (RE) elements. One or more of scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium may be used as rare earth elements. However, it is expensive to isolate the individual rare earth elements, so Misch metal, which is comparatively cheap, may preferably be used.

In Mg-Al-Si based alloys the solubilities of Mn, RE and Fe are mutually restricted. In addition, reduced temperature reduces their mutual solubility.

Several experiments have been carried out and are described in the following examples.

Example 1

Magnesium alloys of the type AS21 have been prepared with different combinations of Mn and RE. Table 1 and Figure 1 shows the different combinations of Mn and RE which are investigated. The Rare Earth elements are added in the form of Misch metal, a mixture of Ce, La Pr and Nd (Approx. 55 weight % Ce, 25 weight %La, 15 weight % Nd, 5 weight % Pr). Other mixtures of Rare Earth elements are expected to give the same effect.

The other elements Al, Si and Zn were held constant within the specification of the alloy, and close to 2.2 %, 1.0 % and 0.2 % respectively. The alloys were prepared by adding controlled amounts of Mn and RE to the alloy at temperatures around 740 °C (for some compositions about 760 °C), and then giving the alloys time to stabilize at specified temperatures before casting of test samples for chemical analysis and corrosion tests. The Fe content of the specimens is a result of the equilibrium condition established.

In addition, unmodified AS21 was also tested and the results are included in Table 1.

The corrosion resistance was determined for gravity cast disc samples by immersing into a solution of 5 % NaCl at 25 °C for 72 hours. The ratio between test solution and sample surface was 10 ml/cm^2 in all the tests. The casting temperature and corrosion rate for gravity cast disc samples are included in Table 1. The corrosion rates are determined by weight loss measurements and are measured in MCD (mg/cm^{2}day).

Table 1. *Casting temperature, composition and corrosion rates for the permanent mold cast medallions included in this investigation.*

Temp. [°C]	Al [weight%]	Zn [weight%]	Mn [weight%]	Si [weight%]	Fe [ppm]	RE [weight%]	Corrosion rate [MCD]
650	2,42	0,19	0,00	0,96	12	0,10	4,9
650	2,18	0,19	0,16	0,99	21	0,00	4,2
650	2,44	0,20	0,03	0,98	6	0,11	1,3
650	2,46	0,20	0,05	0,95	2	0,11	1,6
650	2,40	0,19	0,01	0,99	9	0,09	3,4
660	2,30	0,16	0,24	0,88	4	0,00	4,4
660	2,30	0,17	0,24	1,00	9	0,00	4,0
660	2,40	0,18	0,25	0,91	6	0,00	4,6
660	2,07	0,20	0,06	0,99	4	0,12	1,1

660	2,30	0,18	0,22	0,99	8	0,00	3,9
660	2,30	0,18	0,18	0,94	18	0,00	4,7
660	2,20	0,17	0,17	1,02	27	0,00	4,3
660	2,20	0,17	0,06	0,99	53	0,00	5,5
660	2,18	0,21	0,04	1,01	6	0,13	0,6
660	2,40	0,17	0,00	1,01	75	0,00	88,0
660	2,23	0,21	0,22	1,00	10	0,01	4,4
660	2,26	0,21	0,25	0,86	10	0,01	4,7
660	2,15	0,20	0,12	0,98	5	0,04	2,3
680	2,04	0,20	0,07	0,96	4	0,14	1,0
680	2,30	0,17	0,20	0,96	45	0,00	6,9
680	2,39	0,19	0,01	0,95	14	0,18	5,0
680	2,30	0,18	0,26	1,00	18	0,00	5,4
680	2,48	0,20	0,07	0,98	5	0,17	2,1
680	2,30	0,16	0,31	0,90	6	0,00	5,4
680	2,30	0,17	0,29	0,97	9	0,00	4,7
680	2,40	0,18	0,31	0,90	5	0,00	5,2
680	2,48	0,20	0,01	1,03	16	0,16	6,9
680	2,20	0,17	0,18	1,01	49	0,00	6,4
680	2,30	0,21	0,29	0,87	20	0,01	5,9
680	2,21	0,20	0,20	1,02	52	0,00	6,3
680	2,40	0,18	0,00	1,03	96	0,00	97,3
680	2,23	0,21	0,05	1,01	10	0,16	0,8
680	2,20	0,17	0,06	0,97	73	0,00	8,1
680	2,18	0,21	0,13	1,00	7	0,05	2,0
680	2,45	0,20	0,04	0,99	10	0,18	3,0
680	2,16	0,21	0,24	0,98	22	0,02	5,3
700	2,30	0,17	0,21	0,96	82	0,00	9,4
700	2,28	0,21	0,31	0,87	39	0,02	8,5
700	2,13	0,20	0,10	1,00	5	0,17	1,0
700	2,30	0,17	0,28	1,01	39	0,00	7,3
700	2,22	0,21	0,26	1,01	24	0,03	5,4
700	2,40	0,17	0,00	1,02	113	0,00	93,4
700	2,20	0,17	0,18	1,02	73	0,00	7,8
700	2,20	0,17	0,07	0,98	97	0,00	11,2
700	2,40	0,17	0,36	0,96	6	0,00	6,1
700	2,25	0,21	0,05	1,02	15	0,23	2,2
700	2,23	0,21	0,15	1,01	10	0,08	2,0
700	2,30	0,18	0,39	0,94	8	0,00	6,7
700	2,40	0,15	0,37	0,94	13	0,00	7,4
710	2,21	0,20	0,21	1,03	111	0,00	10,2
710	2,48	0,20	0,04	1,01	25	0,21	6,3
710	2,47	0,20	0,01	1,03	30	0,20	14,6
710	2,46	0,19	0,01	1,01	25	0,28	7,6
710	2,50	0,20	0,08	0,99	20	0,20	3,7
720	2,20	0,17	0,18	1,01	110	0,00	9,7
720	2,30	0,16	0,42	1,01	18	0,00	9,3
720	2,30	0,17	0,00	0,99	149	0,00	95,6

720	2,20	0,17	0,07	0,97	134	0,00	16,4
720	2,22	0,21	0,15	1,01	23	0,11	1,9
720	2,40	0,15	0,42	0,96	29	0,00	10,2
720	2,25	0,21	0,33	0,86	113	0,02	12,0
720	2,30	0,17	0,29	1,00	77	0,00	12,4
720	2,40	0,18	0,44	0,93	15	0,00	10,5
720	2,28	0,21	0,05	1,04	23	0,30	3,3
720	2,24	0,21	0,11	1,03	23	0,19	1,5
720	2,26	0,21	0,27	1,01	40	0,04	6,9
720	2,30	0,17	0,21	0,93	121	0,00	13,0
740	2,30	0,17	0,44	0,97	40	0,00	13,9
740	2,30	0,17	0,21	0,94	155	0,00	18,9
740	2,20	0,16	0,06	0,94	181	0,00	24,5
740	2,30	0,17	0,30	1,13	122	0,00	16,9
740	2,30	0,17	0,18	1,00	135	0,00	13,0
740	2,30	0,17	0,00	0,99	189	0,00	69,1
760	2,30	0,17	0,18	1,00	189	0,00	19,6
760	2,40	0,17	0,00	1,01	243	0,00	60,8
760	2,30	0,17	0,06	0,97	246	0,00	26,4
760	2,30	0,17	0,22	0,93	219	0,00	22,2
760	2,30	0,17	0,30	1,01	150	0,00	19,8

The corresponding Fe contents are shown in Figure 2. The figure includes data from different temperatures. It illustrates that all specimens containing more than 0.05 weight % RE have a Fe content below 40 ppm, while the specimens without RE may contain higher levels of Fe.

The corrosion rates are also given in Tables 1 and 2. The corrosion rates are illustrated vs. Mn and RE contents in Figure 3. The corrosion rate is at a minimum for compositions with a Mn content between 0.05 and 0.2 weight %, and a RE content above 0.05 weight %. Comparing Figures 2 and 3 reveals that there is no direct correlation between the Fe content and the corrosion rates, also the content of Mn and RE has a significant influence.

This can be seen in Figure 4, where the corrosion rates are plotted vs. the content of Mn and Fe, and the minimum is reached when both elements are at a low level. This is, however, not possible to obtain without the addition of other alloying elements, like the RE elements. Furthermore, the corrosion rates increase when the Mn content is below 0.05 weight%. Thus, the presence of a low level of Mn is necessary for an optimum effect.

The effect of RE addition of increased temperature is unexpected. Figure 5 presents corrosion rates vs. RE content and casting temperature for the gravity cast disc samples containing a minimum of 0.045 weight% Mn. Due to the increased solubility of Mn and Fe with increased temperature, increased temperature has a strong negative effect on the corrosion resistance of unmodified AS21. With the addition of RE elements, the equilibrium levels of Mn and Fe are strongly reduced also at higher temperatures, thereby significantly reducing the corrosion rates.

Example 2

The alloy AS21 is produced for application as a die casting alloy. A selected set of compositions, as shown in Table 2, was therefore die cast into test plates, and tested in salt-spray according to ASTM standard no. B117-90. The corrosion results are included in Table 2 and are shown in Figures 6 and 7. There is correspondence between the corrosion rates determined for die cast plates and gravity cast disc samples. An optimum composition range is found for compositions with 0.05 - 0.2 weight % RE, and 0.05 - 0.2 weight % Mn.

Table 2. *Casting temperature, composition and corrosion rates for the die cast test plates included in this investigation. The corrosion rates are determined after 240 hours exposure in salt-spray.*

Temp.	Al	Zn	Mn	Si	Fe	RE	Corrosion rate
[°C]	[weight%]	[weight%]	[weight%]	[weight%]	[ppm]	[weight%]	[MCD]
720	2,25	0,21	0,33	0,86	113	0,02	13,6
700	2,28	0,21	0,31	0,87	39	0,02	4,5
680	2,30	0,21	0,29	0,87	20	0,01	1,8
660	2,26	0,21	0,25	0,86	10	0,01	0,3
720	2,26	0,21	0,27	1,01	40	0,04	2,1
700	2,22	0,21	0,26	1,01	24	0,03	1,7
680	2,16	0,21	0,24	0,98	22	0,02	1,1
660	2,23	0,21	0,22	1,00	10	0,01	0,6
720	2,22	0,21	0,15	1,01	23	0,11	0,4
700	2,23	0,21	0,15	1,01	10	0,08	0,2
680	2,18	0,21	0,13	1,00	7	0,05	0,2
660	2,15	0,20	0,12	0,98	5	0,04	0,1
720	2,24	0,21	0,11	1,03	23	0,19	0,7
700	2,13	0,20	0,10	1,00	5	0,17	0,0
680	2,04	0,20	0,07	0,96	4	0,14	0,3
660	2,07	0,20	0,06	0,99	4	0,12	0,1
720	2,28	0,21	0,05	1,04	23	0,30	0,5
700	2,25	0,21	0,05	1,02	15	0,23	0,5

680	2,23	0,21	0,05	1,01	10	0,16	0,2
660	2,18	0,21	0,04	1,01	6	0,13	0,0

In addition to die casting of test plates, large engine parts with casting weights of 20 kg have been cast from the alloy. In comparison with the unmodified AS21, the castability was not significantly affected.

The mechanical properties of the alloys are governed by the content of Al, Si, and Zn, and is not significantly affected by the modification by addition of RE elements.

Example 3

Two melts, each of 150 kg Mg alloy were produced in the foundry lab. Each of the melts were produced with 1.5 % Al, 1.0 % Si and 0.2 % Zn. One melt was produced with 0.4 % added Mn, the other with 0.3 % RE + 0.1 % Mn. The alloys were produced at 740 °C, thereafter stabilised at 680 °C for at least 1 hour before casting of permanent mould cast disc samples and 3 mm die cast test plates. Each melt was further alloyed with super purity Al in steps of 1 % to cover the Al-range given in claim 1. This alloying was done at 680 °C, and the alloys were stabilised for at least 1 hour before further casting. The chemical analysis of each composition is shown in Table 3. The analysis was carried out by spark emission spectrograph, the RE-elements by ICP-AES.

Table 3. *Chemical compositions of the investigated specimens*

Speci-men I.D	Al [wt%]	Zn [wt%]	Mn [wt%]	Si [wt%]	Fe [wt%]	Cu [wt%]	Ni [wt%]	Be [ppm]	Sum RE [wt%]
U-1	1.388	0.201	0.269	0.9334	0.0018	0.0002	0.0002	0.9	0
U-2	2.322	0.208	0.258	0.9108	0.0027	0.0002	0.0002	0.9	0
U-3	3.203	0.205	0.256	0.9065	0.0034	0.0002	0.0002	0.9	0
U-4	4.092	0.207	0.264	0.9143	0.0047	0.0002	0.0002	0.9	0
U-5	4.974	0.205	0.286	0.9248	0.0056	0.0002	0.0002	0.9	0
M-1	1.490	0.202	0.074	0.8880	0.0022	0.0002	0.0002	0.9	0.16
M-2	2.544	0.207	0.071	0.9065	0.0029	0.0002	0.0002	0.9	0.15
M-3	3.463	0.204	0.070	0.8835	0.0041	0.0002	0.0002	0.9	0.16
M-4	4.421	0.206	0.070	0.9103	0.0048	0.0002	0.0002	0.9	0.16
M-5	5.349	0.210	0.087	0.9323	0.0123	0.0002	0.0002	2.8	0.2

Four die cast test plates from each composition were tested in salt-spray for 10 days according to ASTM B117. The results are shown in Table 4, and in Figure 8. For some of the compositions there were single results diverging significantly from the rest of the same series. The average results without the outliers are shown in Figure 9. The outliers are here defined as single results lying more that 4x standard deviation outside the average of the other parallels. These are also marked in Table 4.

Table 4. *Corrosion test results in MCD ($\frac{mg\ weight\ loss}{cm^2 \times day}$). Outliers are marked with bold italic*

Speci-men I.D.	MCD	MCD	MCD	MCD	Mean	Std Dev.	Mean ex outlier	Std dev. ex outlier
U-1	1	1.2	1.3	***4.3***	2.0	1.6	1.17	0.12
U-2	0.3	0.4	0.7	***7.8***	2.3	3.7	0.47	0.17
U-3	0.51	0.6	0.7	***2.4***	1.1	0.9	0.60	0.08
U-4	0.32	0.38	0.42	***0.9***	0.5	0.3	0.37	0.04
U-5	0.24	0.31	0.31	0.33	0.3	0.04	0.30	0.03
M-1	0.07	0.07	0.08	0.09	0.08	0.01	0.08	0.01
M-2	0.05	0.05	0.09	***0.26***	0.11	0.1	0.06	0.02
M-3	0.03	0.03	0.04	0.06	0.04	0.01	0.04	0.01
M-4	0.03	0.04	0.04	0.05	0.04	0.01	0.04	0.01
M-5	0.04	0.06	0.06	***0.21***	0.09	0.08	0.05	0.01

The compositions of the two series are very similar, except for the Mn and the RE content. Even though super purity Al was used, the Fe-content is increasing together with the Al-addition. This Fe-pick up was fairly similar for the two series, except at the highest Al-level, where the RE-modified alloy reached 123 ppm Fe, compared to 56 ppm in the unmodified.. For the series without RE, the corrosion rates decreases with increasing Al, in spite of the increasing Fe. For the series modified with RE, the corrosion rates are significantly lower, and no obvious trends with variation of Al and Fe can be seen. The results clearly show that the corrosion rates of the RE-modified alloy is significantly lower than for the unmodified alloy through the whole Al-composition range. For several compositions there are outliers with significantly higher corrosion rates than the other specimens from the same series. The background for these high individual results are not investigated. These outliers are not influencing on the conclusion of this investigation.Thus, the modification of AS-alloys by substituting some of the Mn with

RE-elements has a significant positive effect on the corrosion resistance over the whole composition range of 1.5 - 5 % Al.

The corrosion resistance of magnesium-aluminium-silicon based alloys is significantly improved by the addition of RE elements by:

1) Reducing the solubility of Mn

2) Reducing the solubility of Fe

3) Modifying the corrosion behavior by the presence of RE. The presence of small amounts of Mn (above 0.01 weight %) is necessary for an optimum effect of the modification.

This positive effect of RE elements on corrosion resistance will also apply for other levels of Si and Zn in the AS-alloys.

Patent claims

1. Magnesium based alloy with improved corrosion resistance, containing 1.5-5 weight % Al, 0.6-1.4 weight % Si, 0.01-0.6 weight % Mn, 0.01-0.4 weight % RE.

2. Magnesium alloy according to claim 1, wherein the alloy contains until 0.5 weight % Zn.

3. Magnesium alloy according to claim 2, wherein the Zn content is in the range 0.1-0.3 weight %.

4. Magnesium alloy according to claim 1, wherein the Mn content is in the range 0.01-0.3 weight %.

5. Magnesium alloy according to claim 1, wherein the rare earth elements are Misch metal.

6. Magnesium alloy according to claim 1 - 2, comprising 1.9-2.5 weight % Al, 0.7-1.2 weight % Si, 0.15-0.25 weight % Zn, 0.01-0.3 weight % RE and 0.01-0.2 weight % Mn.

7. Method of improving the corrosion resistance of magnesium, aluminium, silicon alloys where Mn is added in order to reduce Fe impurities, by keeping both Mn and Fe at a low level by adding small amounts of RE.

8. Method according to claim 7, where the Mn content is kept above 0.01 weight % .

9. Method according to claim 7, wherein the RE content is kept in the range 0.01-0.4 weight % .

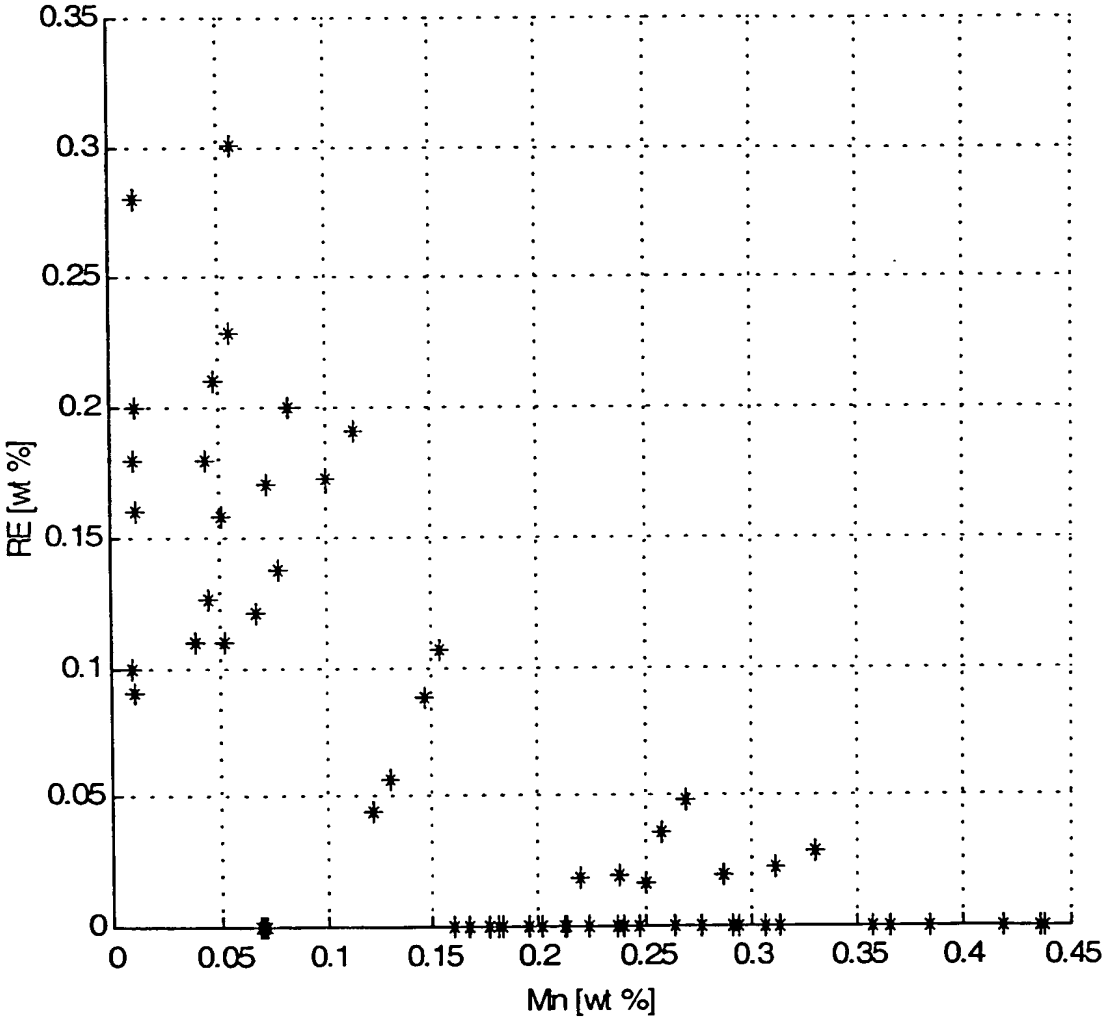
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
RE [wt %]
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Mn [wt %]

FIG. 1

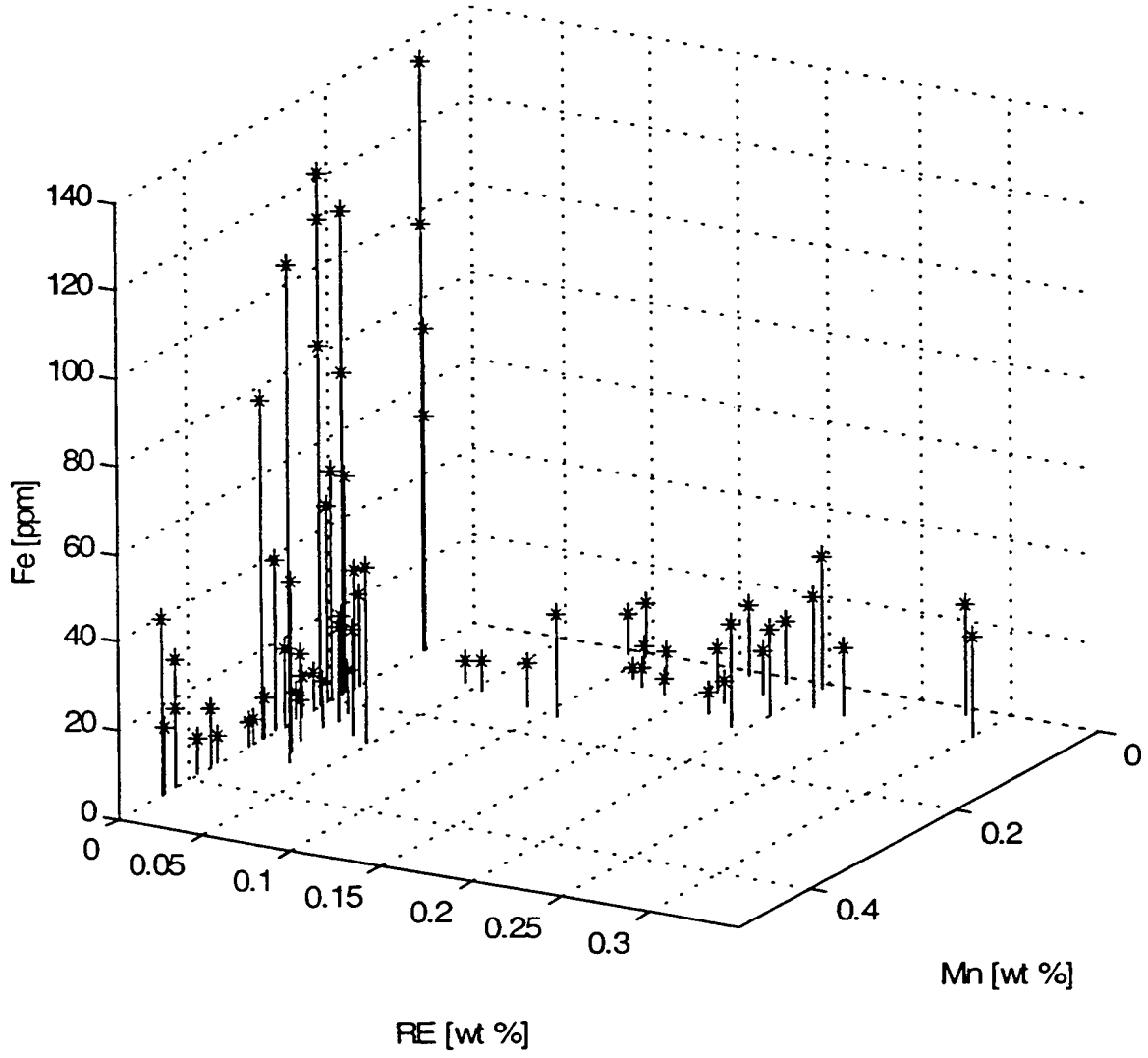
140
120
100
80
60
40
20
0
Fe [ppm]
0
0.05
0.1
0.15
0.2
0.25
0.3
RE [wt %]
0
0.2
0.4
Mn [wt %]

FIG.2

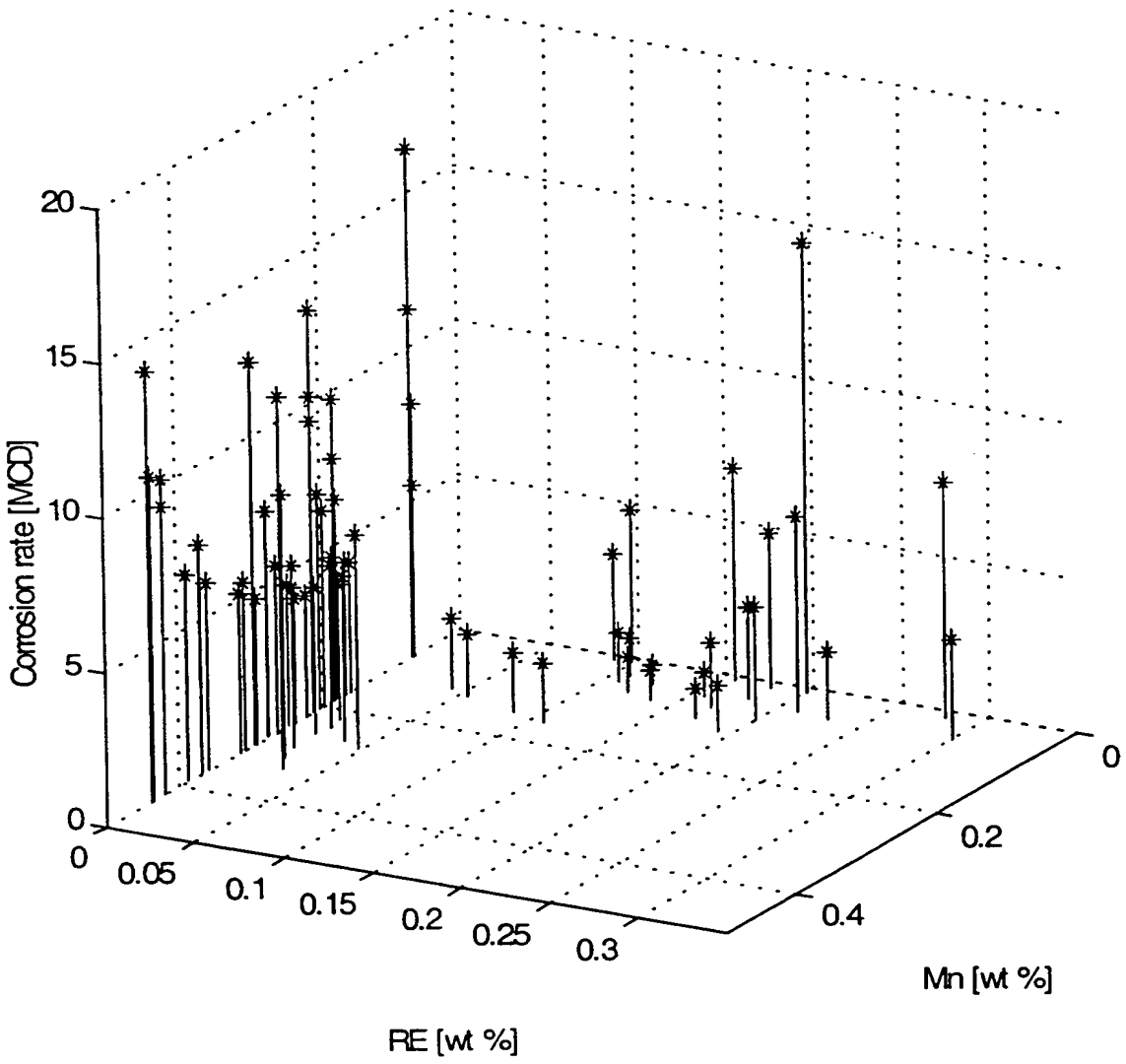
20
15
10
5
0
Corrosion rate [MCD]
0
0.05
0.1
0.15
0.2
0.25
0.3
RE [wt %]
0
0.2
0.4
Mn [wt %]

FIG. 3

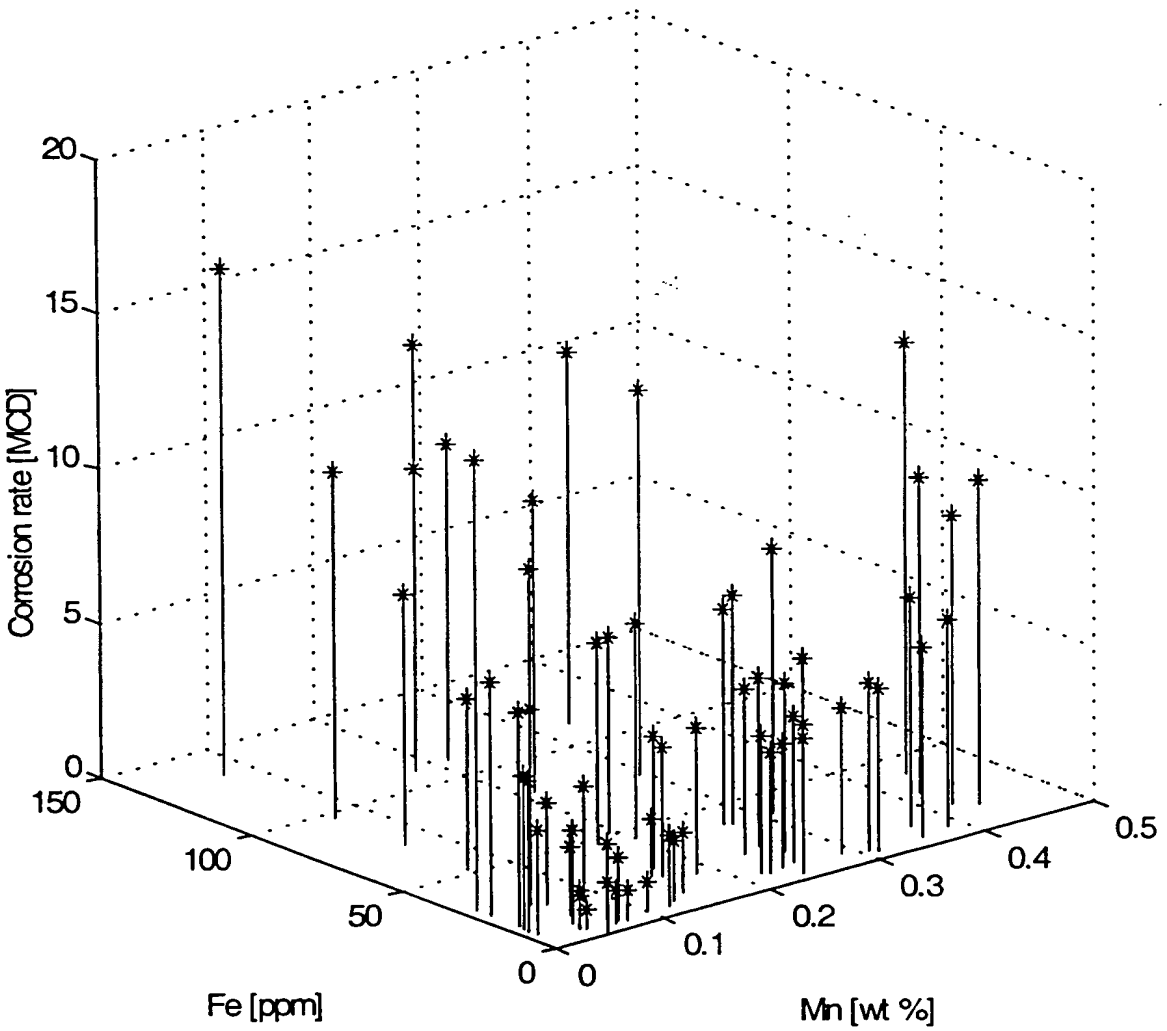
Corrosion rate [MCD]
20
15
10
5
0
150
100
50
0
Fe [ppm]
0
0.1
0.2
0.3
0.4
0.5
Mn [wt %]

FIG. 4

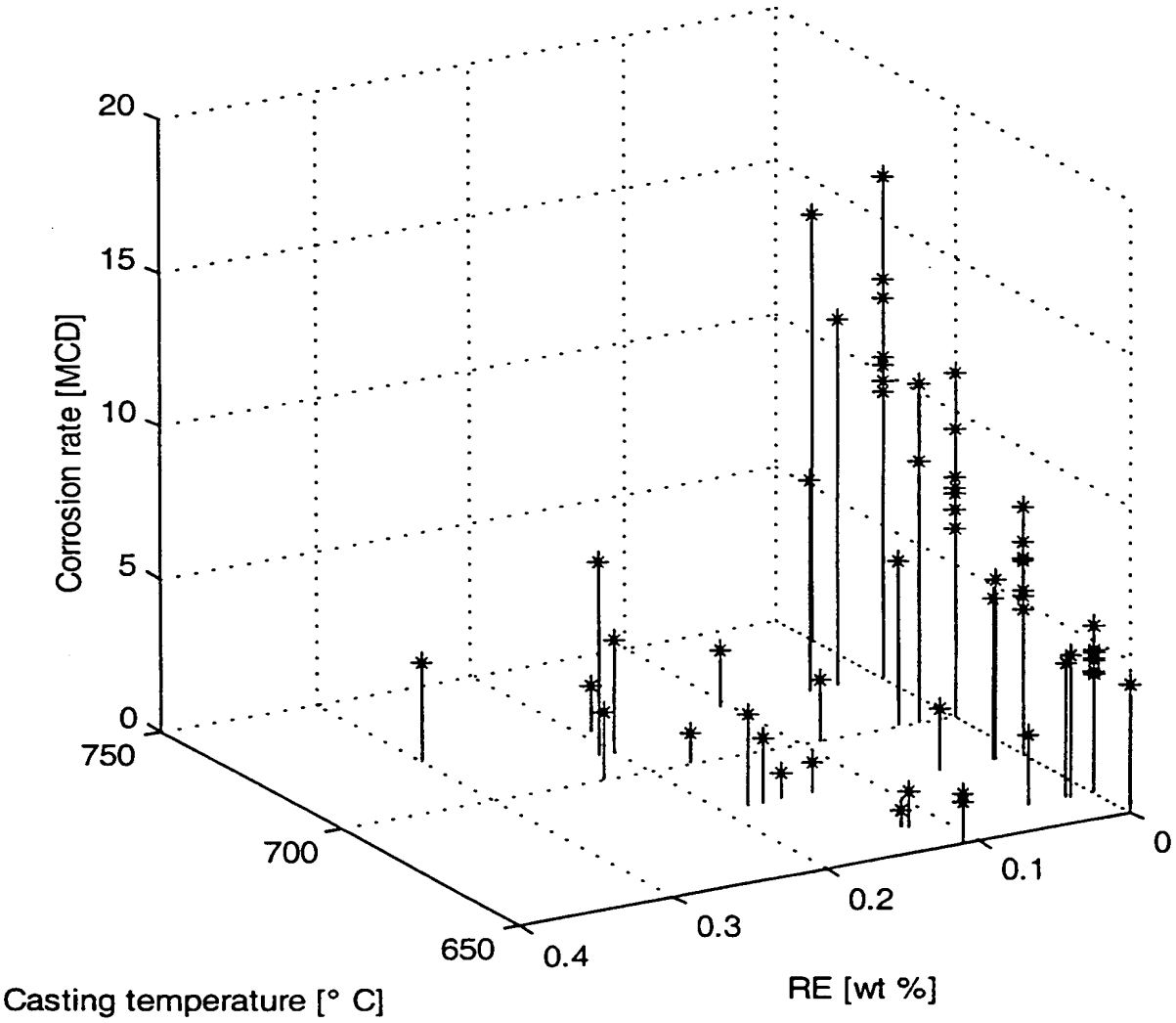
20
15
10
5
0
Corrosion rate [MCD]
750
700
650
Casting temperature [° C]
0.4
0.3
0.2
0.1
0
RE [wt %]

FIG. 5

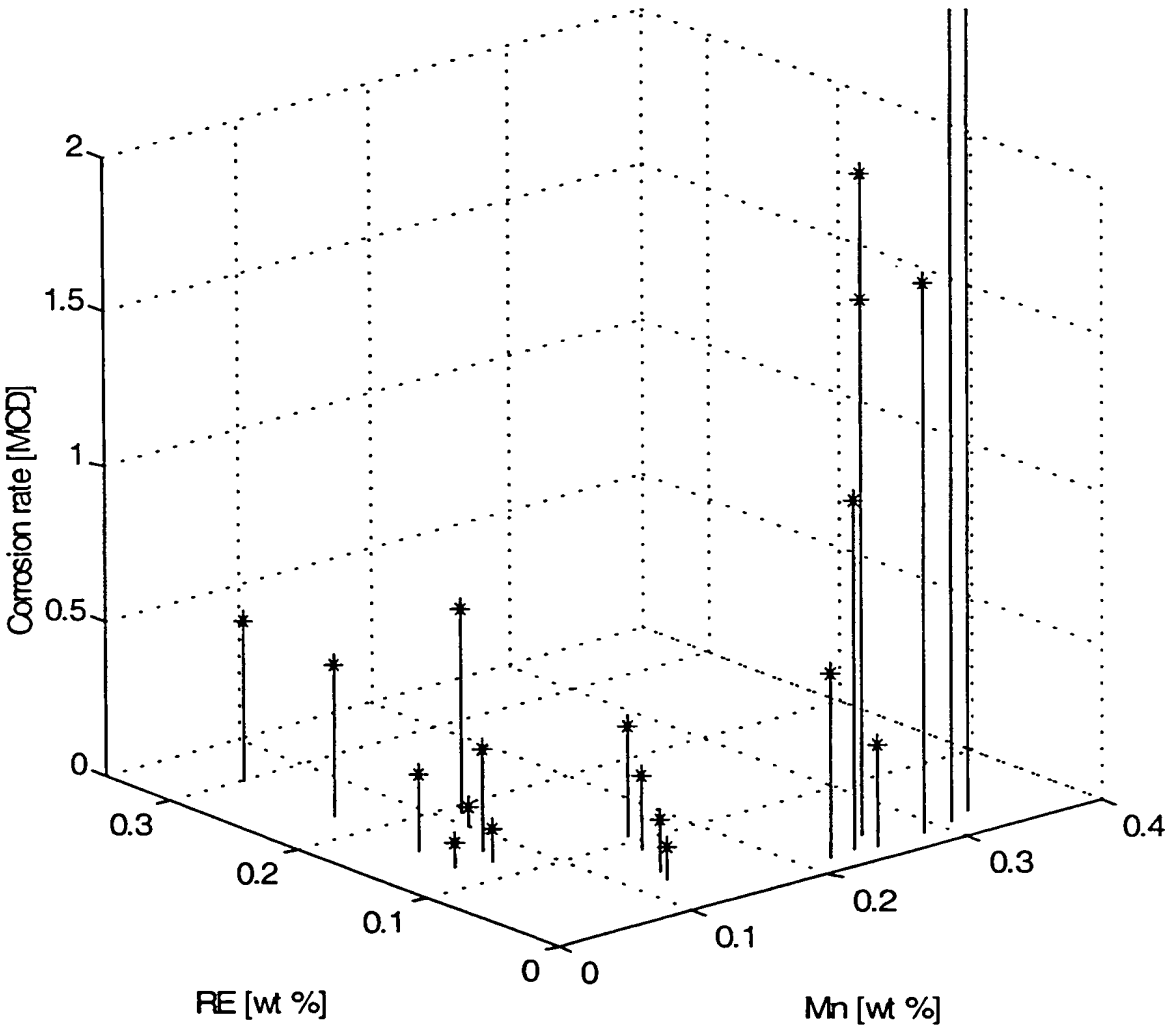

FIG. 6

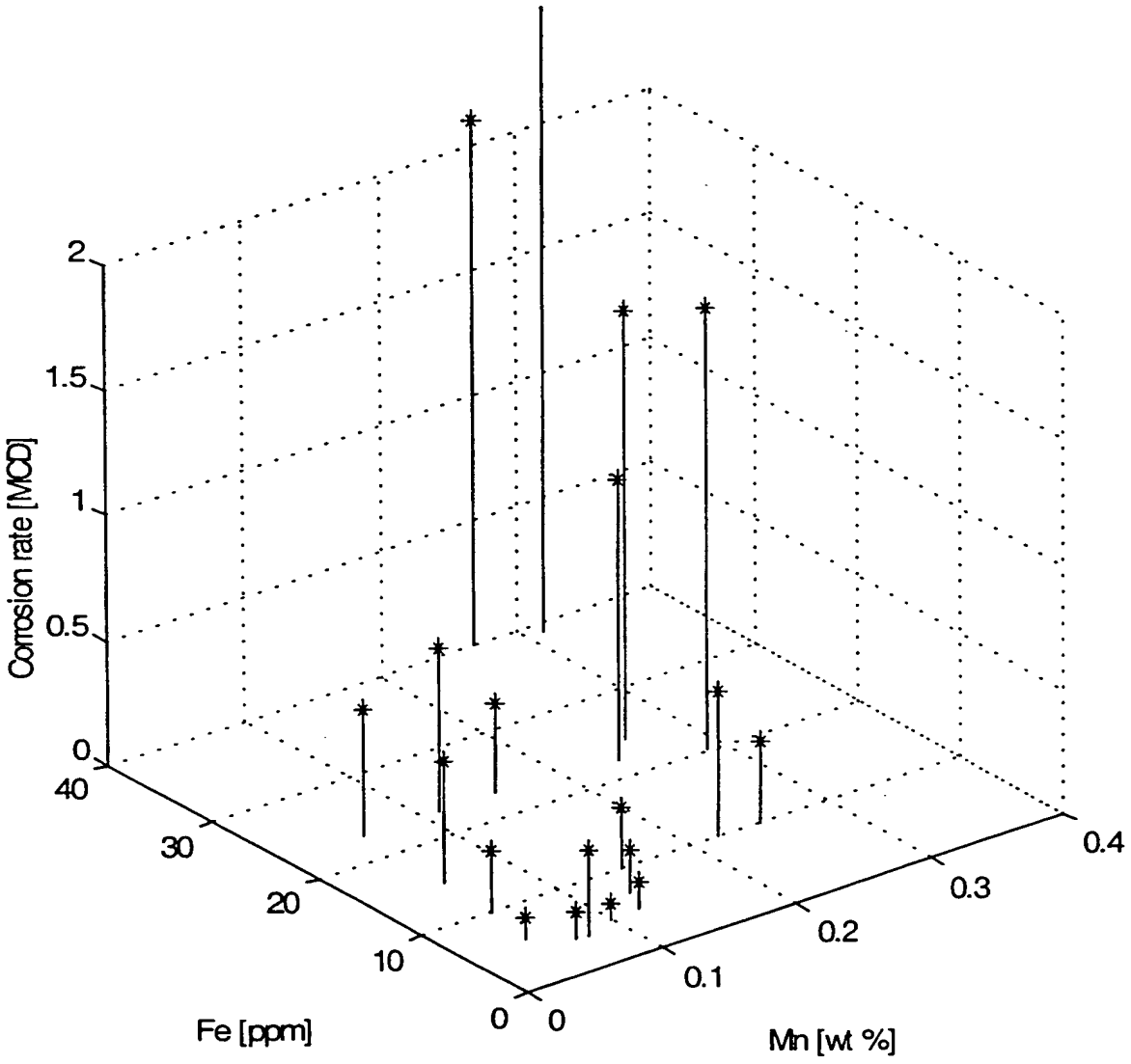
Corrosion rate [MCD]
2
1.5
1
0.5
0
40
30
20
10
0
Fe [ppm]
0
0.1
0.2
0.3
0.4
Mn [wt %]

FIG. 7

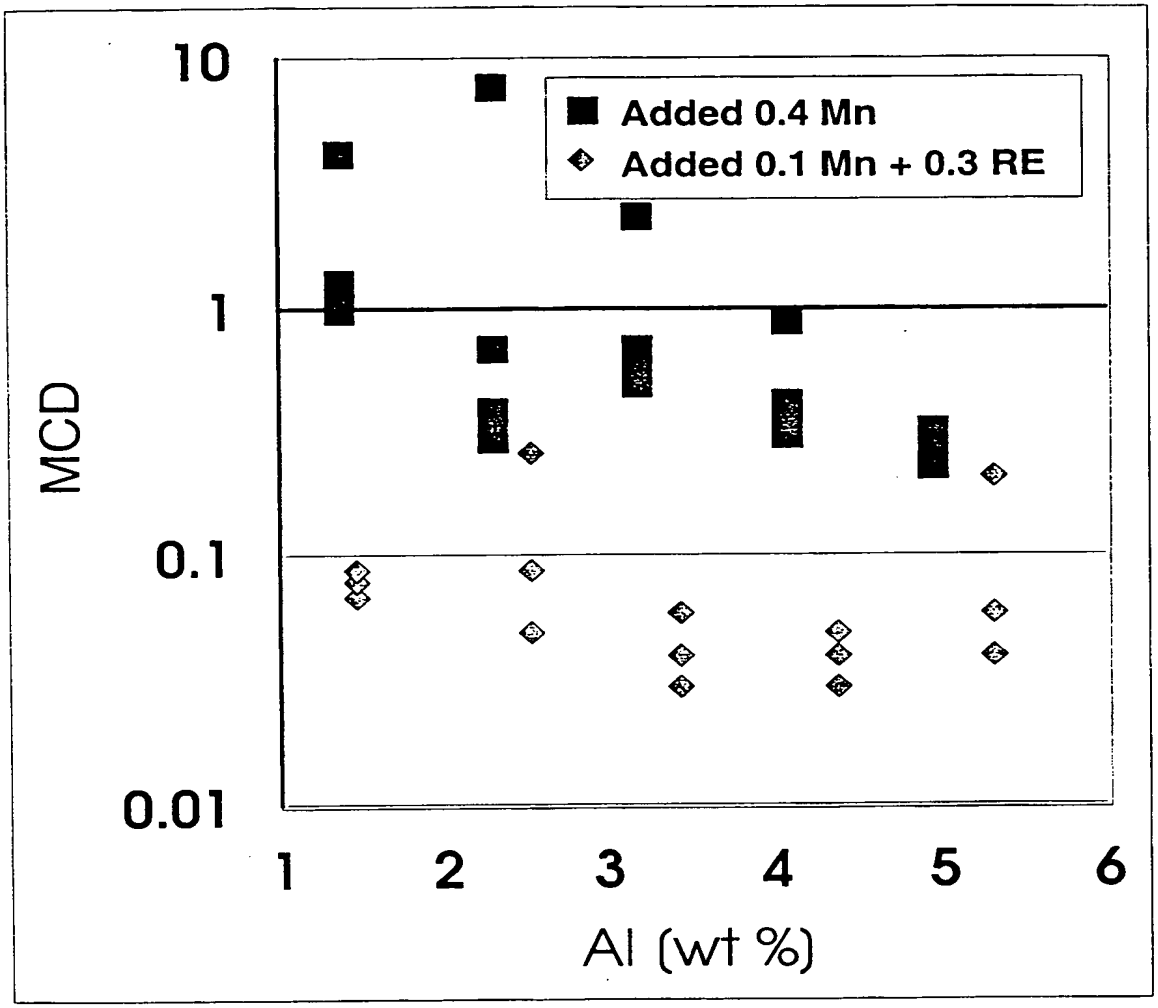

FIG. 8

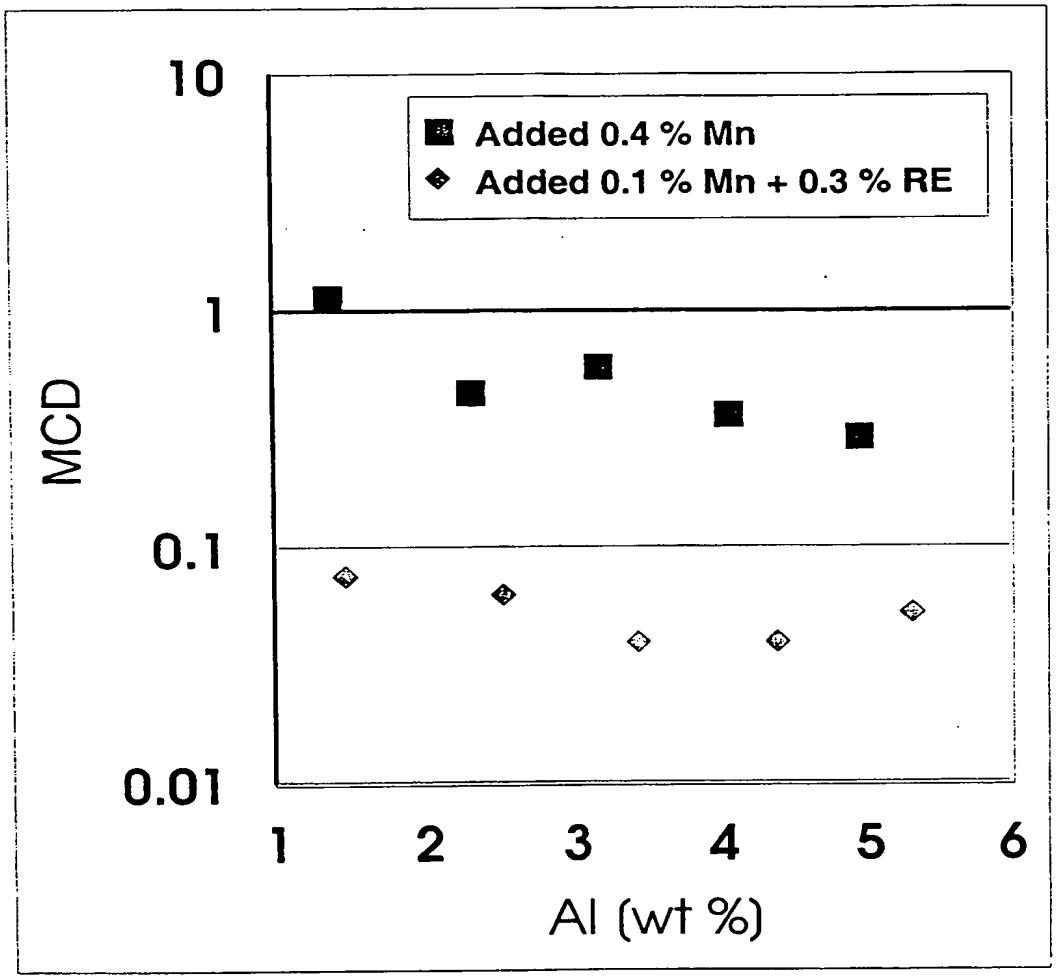

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 99/00324

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C22C 23/02, C22C 23/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, METADEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0524644 A1 (TOYOTA JIDOSHA KABUSHIKI KAISHA), 27 January 1993 (27.01.93), page 5, line 15 - page 8, line 30, claims 1-18 --	1-6
A	NO 121753 B (THE DOW CHEMICAL COMPANY), 5 April 1971 (05.04.71) --	1-6
A	FR 1555251 B (THE DOW CHEMICAL COMPANY), 24 January 1969 (24.01.69) --	1-6
A	US 3718460 A (GEORGE S. FOERSTER), 27 February 1973 (27.02.73) -- --------	1-6

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 April 2000	08 -05- 1999
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM	Authorized officer Nils Enqnell/MP

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO99/00324

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

See extra sheet

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Independent claim 7 is so obscure that it is not possible to carry out a meaningful search. There is no definition of any grade of alloy for which the method is applicable. In fact, with the actual wording, it is not even defined which metal is the base metal. "Fe impurities" is not defined and it is not explained in what way such impurities are reduced. Therefore, a search report is not established in respect to claims 7-9.

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.
PCT/NO 99/00324

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0524644 A1	27/01/93	DE 69214735 D,T	20/03/97
		JP 5033096 A	09/02/93
		US 5336466 A	09/08/94
		US 5552110 A	03/09/96
		JP 5171333 A	09/07/93
NO 121753 B	05/04/71	DE 1608136 A	22/10/70
		FR 1555251 A	24/01/69
		GB 1216377 A	23/12/70
		JP 49004122 B	30/01/74
FR 1555251 B	24/01/69	DE 1608136 A	22/10/70
		GB 1216377 A	23/12/70
		JP 49004122 B	30/01/74
		NO 121753 B	05/04/71
US 3718460 A	27/02/73	NONE	

US 1001943105P1

Creation date: 04-17-2004
Indexing Officer: THOANG5 - TU ANH HOANG
Team: OIPEBackFileIndexing
Dossier: 10019431

Legal Date: 03-18-2002

No.	Doccode	Number of pages
1	M905	2

Total number of pages: 2

Remarks:

Order of re-scan issued on .....